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The impact of climate change and energy resources on biodiversity loss: Evidence from a panel of selected Asian countries

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ABSTRACT

This study examined the relationships between climate change, energy resources, growth specific factors and their resulting impact on biodiversity loss in a panel of 18 selected Asian countries during the period of 2000–2014. The study employed panel fixed effect regression and panel quantile regression to assess the influence of different factors on biodiversity loss at low, medium, and high levels quantile distribution. The results show that climatic factors increase aquaculture production, whereas energy sources and growth specific factors affected the production of aquaculture in a panel of selected countries. Potential habitat area is affected by high population growth and renewable energy consumption whereas Global Environment Facility (GEF) biodiversity index is affected by average precipitation, foreign direct investment (FDI) inflows, and per capita income. Climatic factors and renewable energy both supported the total fisheries production, whereas nitrous oxide emissions, renewable internal freshwater resources, FDI inflows, per capita income, and population growth affected the production of total fisheries at different quantile distributions.

1. Introduction

According to Intergovernmental Panel on Climate Change [1] report, climatic variability is the global environmental concern that required a sustainable policy for addressing climate change and its consequential impact on extreme temperature, rising sea level, ecological plant and animal species, land use management, and ecosystem. It is desirable to formulate policies for mitigating Greenhouse Gas (GHG) emissions and reduced it limits within the threshold level ranging between 450 and 550 parts per million. Akram (2012, p, 1) argued that *"Asia is recognized as one of the most vulnerable regions to climate change on the planet. With approximately 60 percent of world's population residing in Asia, this phenomenon presents serious concerns for policymakers in the region"*.

Asia is the largest region of the World that severely affected by climate change and energy security issues. Agricultural production is affected about 4% due to climate change and global warming, while net farm revenue is lost by 3% due to rise in 7% precipitation rate by rising 2 °C temperature. In addition, wheat and other agricultural crops also affected due to uneven rain fall that reduced agricultural productivity which seriously undermines Asian economy [2]. Clean energy policy is the policy dream for the Asian countries to mitigate greenhouse gas emissions and air pollutants that support to the Asian environment including ecosystem, fresh water resources, ecological species, human's health, economic wealth, and conservation of biodiversity. Table 1 summarizes the different factors that affect biodiversity in Asia including climate change, energy sources, and growth specific factors.

The study employed panel fixed effect and panel quantile regression in order to analyze the influencing factors that affect biodiversity at low, medium, and high-level with different quantiles distribution in a panel of selected Asian countries. This study

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Table 1
Factors affecting biodiversity loss in Asia.

Factors	Link to Biodiversity loss	Conservation Strategy
Climate Change	- Animal and plant species respond to the climatic variability in terms of reproduction, migration, and distribution of species from their normal flora. - Climate change affects the ecological species via the channel of agriculture production and environmental health. - Extreme temperature and rising sea level affects biodiversity. - Carbon dioxide emissions and greenhouse gas emissions largely affect the environment and economic considerations including health and wealth issues.	- Deforestation is an important factor that largely affects the biological diversity in the form of potential species loss, loss of herbs for medication purposes, and destruction of flora and fauna. The policies should be made to reduce deforestation in order to preserve our natural resources and ecological species for balancing the natural flora. - Low carbon and mitigate GHG emissions is desirable for sustainable policy. The intervening eco-friendly policies to avoid dirty pollution games through proper waste disposal and waste recycling helpful to reduce biodiversity loss. - High temperature affects early plant pollination process that changes the distribution of species. It further raises sea level that threatens to global biodiversity. The early lookup these problems to formulate policies to decrease the problem of global warming and alteration of early species reproduction made a way of sustainable journey.
Energy Sources	- The resulting impact on environment by fossil fuel energy consumption leads to carbon dioxide emissions ultimately increases greenhouse gas emissions that damage the ecosystem and global biodiversity.	- Conservation and efficiency measures may preserve the ecological species through improved management of habitat corridors, renewable internal fresh water resources, reforestation, clean air, etc.
Population growth	- The rapid population growth cumbersome the economic and environmental resources that further affected natural ecosystem and biodiversity. The following threats to biodiversity by human made activities and its rapid growth are as follows, i.e., a) Potential habitat area is affected. b) Imbalance of ecological equilibrium. c) Emerged new and toxic air pollutants. d) Climate change effects. e) Over and under exploitation of economic and natural resources etc.	- Conservation of biodiversity resources required population control strategies, environmental legislations, restricted dirty pollution by imposing environmental taxes, decrease deforestation, used renewable energy sources, produce environmental goods, and fully utilized economic and environmental resources.

Source: [1,3–6].

has a unique distinction in the academic literature; as its first examine the relationship between climate change, energy resources, growth specific factors and their resulting impact on biodiversity loss, while at the other hand, it's further assess the mean variations of explanatory factors on dependent variables at 25th, 50th and 75th quantiles distribution.

The importance of energy sources, growth factors, and environmental consideration is crucial for attaining sustainable development to conserve biodiversity in Asia. The main contribution of the study is to used number of climatic factors, including, average precipitation, carbon dioxide (CO_2) emissions, and GHG emissions, while previous studies limited to single or two factors (see, [7–10]; etc.). In addition, there are few studies that used average precipitation as a climatic factor under the protection of Kyoto protocol for biodiversity (see, [11–13,87] etc.). The climatic factors confined the need of appropriate balance between human actions and biodiversity conservation that is vital for environmental sustainability agenda across countries. Besides climatic factor, this study takes an initiative to add renewable energy resources, which is vital for sustainable development. The energy sources include nitrous oxide emissions of energy sector, renewable energy consumption, and renewable internal fresh water resources, all these resources helpful to reduce the environmental impacts on biodiversity loss across Asian countries. The previous studies confirmed the importance of renewable energy sources in sustainable development (see, [14]; [15–17]; etc.). The representation of biodiversity is followed by the following four promising variables, including, aquaculture production, forest area, Global Environment Facility (GEF) benefits biodiversity index, and total fisheries production. The GEF biodiversity index is utilized in the study of Zaman [10] and Zaman et al. [18]; where carbon emissions and biofuel production damages the biodiversity across the globe. Similarly, there are number of studies that utilized forest area as a proxy for 'potential habitat area' or biodiversity (see, [19,88] etc.), hence, this study used the same proxy for the biodiversity loss across Asian countries. It is evident that global biodiversity is linked with the fresh water consumption [20], human population, and food production [21], while it is imperative to improve the water resources and aquaculture sources/marine sources both for human and fisheries [22]. These are the vital sources, which we considered in this study to use for specific factors of climate change, energy sources and biodiversity loss to propose an integrated sustainable agenda that support to the United Nations Kyoto protocol for biodiversity conservation for Asian countries.

The objective of the study is to examine the relationships between climate change, energy sources, growth specific factors, and biodiversity loss in a panel of 18 selected Asian countries during the period of 2000–2014. The more specific objectives are:

i) To what extent have average precipitation, carbon dioxide emissions, and GHG emissions affect the aquaculture production, forest area, GEF benefits biodiversity index, and total fisheries production by using panel fixed effect and panel quantile regression.
ii) To investigate the impact of nitrous oxide emissions of energy sector, renewable energy consumption, and renewable internal fresh water resources affect the biodiversity factors at low-level, medium-level, and high-level quantile distribution.
iii) To examine the relationship between FDI inflows, GDP per capita, population growth, and their resulting impact on biodiversity factors in a panel of Asian countries.

The study divided in to the following sections: after introduction which is presented in Section 1 above, Section 2 shows the review of literature. Section 3 shows the data and methodology, Section 4 discussed the results and final Section 5 concludes the study.

2. Literature review

The relationship between climate change and biodiversity loss is

obvious with different economic and environmental channels through which climatic factors affected biodiversity, while the quest of renewable energy sources is one of the desirable way to mitigate GHG emissions and air pollutants to conserve our natural resources and biodiversity across the globe. There are different streams of literature available that confirm the channel through which climate change affects the biodiversity, i.e., i) extreme weather and temperature affect the ecosystem and biodiversity [23–31] etc), ii) Carbon dioxide emissions affect the forest biodiversity [19,32–36] etc.), and GHG emissions affect the biodiversity and potential habitat area [37–42] etc.). These studies directly and/or indirectly related with the climatic affects of biodiversity loss, land use management, potential habitat area, ecological animal and plant species, carbon management, deforestation, mitigation GHG emissions, weather and extreme temperature, etc. The policies to mitigate the climate change impact on biodiversity are required economic policies intervention to balances the natural environment.

It is evident that renewable energy sources and fresh water resources support the potential of biodiversity across countries. Groom et al. [43] emphasized the need of adaptation of biodiversity-friendly energy sources that lessen the climatic affect on biodiversity loss and support the sustainable environment by biofuel energy that have a zero carbon balance in the residual. However, the study discussed the possible opportunities and threats regarding the adaptation of biofuel energy in conservation of global biodiversity. Jackson [44] investigated the relationship between renewable energy sources and biodiversity loss, and criticizes the European Union biodiversity regulation program and existing large energy renewable projects for evaluating 'Natura 2000' project. The results indicate that this project required more energy to conserve natural environment including balancing the biodiversity and ecosystem with appropriate renewable energy mix across the Europe. Stone et al. [45] argued that artificial lightening (source of energy) is the major determinately factor that not only affects natural environment while it has a greater impact on biodiversity loss. The policies to adopt new sources of energy to support biodiversity are the focal agenda for the policy makers to promote green energy across the globe. Hosseini et al. [46] reviewed the potential of renewable energy that supports the environmental sustainability in Iran and found that abundance of fossil fuel energy is the main detrimental factor that affects the country's environment and sustainability agenda. The country's required renewable energy mix in their energy agenda to promote clean and healthy environment. The study suggested that solar energy, hydropower energy, biofuel, wind energy and geothermal energy are the main sources of renewable energy mix that can be taken benefited for green energy in a country.

The rapid economic growth disgrace the environmental sustainability process that affected biodiversity and natural environment. The policies to reduce negative externalities of environment by balancing the economic factors would helpful to device long-term sustainable policies for healthy and clean environment. Per capita income, FDI inflows, and population growth are the strong predictors to influence biodiversity across the globe. Forester and Machlist [47] identified human footprints on biodiversity by using the ecological data from 107 countries and found that human factor affect the biodiversity, which ultimately affect on potential habitat area of ecological plant and animal species. The human based environmental modeling required more comprehensive survey to evaluate the potential biodiversity loss from socio-economic factors and outlined these factors for environmental conservation strategies. Asafu-Adjaye [48] investigated the relationship between economic growth and environmental degradation in a form of biodiversity loss across countries. The results show that economic growth damages the natural environment particularly in low income countries that required desirable economic and institutional policies to support potential of biodiversity in a region. Mozumder et al. [49] used a multivariate ecological index, including species, genetic, and ecosystem diversity that represent number of factors for biodiversity loss, which were previously limited with a single ecological factor. The study examined the relationship between per capita income and multivariate ecological index in an EKC framework and found a no/flat relationship between them. Jha and Bawa [50] investigated the correlation between human development, population growth and deforestation across developed and developing countries and found two interesting results, i.e., low human development lead to increase deforestation under high population growth while high human development lead to reduce deforestation despite high population growth. The results emphasized the need of human development that may reduce the strain of environment degradation through appropriate economic and health policies across the globe. [51]; p. 1399) concluded that, *"… … quality of the regulatory framework in terms of its certainty and transparency has a greater influence on foreign investors' choice of location than the level of environmental regulatory measures"*. Jacobsen and Hanley [52] examined the relationship between per capita income and biodiversity conservation, and found that biodiversity conservation process increases with the nation's economic health; however, the willingness to pay for biodiversity conservation is less than the growth of income, which should be more elastic. Mills and Waite [53] examined the relationship between economic growth and biodiversity loss under the premises of environmental Kuznets curve (EKC) by using a panel of 35 tropical countries and found some initial traces of EKC hypothesis, however, this relationship further tend to exhibit the reverse hypothesis and concluded that per capita income is not a reliable and feasible growth strategy to improved conservation practices among the countries. Mak-Arvin and Lew [54] investigated the relationship between ecological indicators and foreign aid in a panel of poorer countries and found that foreign aid increases ecological injury in a form of increasing carbon damage, deforestation, and water pollution. The policies to reduce ecological injury by appropriating environmental and economic policies would support the ecological conservation in poorer countries. Chakraborty and Mukherjee [55] concluded that FDI inflows, merchandize exports, and corruption adversely affected the environmental sustainability process in a panel of 114 countries, while human development and political rights are the important factors for environmental sustainability in low income countries. Jiang [56] examined the trivariate relationship between FDI inflows, population growth and environmental degradation in Chinese regions and found an inverted U-shaped relationship between them. [57]; p. 23) highlighted some economic and environmental dimensions to discuss the biodiversity issue in academic and research arena and argued that, *"Human population growth and resource use, mediated by changes in climate, land use, and water use, increasingly impact biodiversity and ecosystem services provision. However, impacts of these drivers … … … are rarely analyzed simultaneously and remain largely unknown"*.

The above studies confirm the strong correlation between climate change, energy sources, growth specific factors, and biodiversity loss in a different economic setting. This study used number of promising variables that quantified the impact of climate change, energy sources, and growth specific factors on biodiversity loss in a panel of selected Asian countries by using a consistent time series data from 2000 to 2014. The study employed panel fixed effect and panel quantile regression to assess the main influencers that affect the biodiversity factors at three different

quantile distribution i.e., 25th quantile, 50th quantile, and 75th quantile, which further compared the estimates of panel least square regression with panel quantile regression under conditional distribution.

3. Empirical model

This study used panel regression and panel quantile regression for examine the relationships between climate change, energy sources, and biodiversity loss in a panel of 18 selected Asian countries for a period of 2000–2014. The study used average precipitation (avgprcpt), carbon dioxide emissions (co2), and total greenhouse gas emissions (ghg) that served as a proxies for climate change; nitrous oxide emissions (n2o) released by energy sources, renewable energy consumption (rec), and renewable fresh water resources (rifr) served as a proxy for energy sources; foreign direct investment inflows (fdi), GDP per capita (gdp), and population growth (popgr) served as a proxy for growth specific factors; and aquaculture production (aquacpd), forest area (farea), GEF biodiversity index (gef), and total fisheries production (tfishpd) served as a proxy for biodiversity. Biodiversity factors served as a 'response' variable while climate change, energy sources, and growth specific factors served as explanatory variables of the study.

The neoclassical environmental economics provide the basis for environmental protection and balancing the ecosystem by sustainable production and consumption through which we achieved by cleaner production techniques. Solow [58] presented the growth matrix where output is determined by three economic factors, including labor, capital and technology/knowledge. The labor is augment with knowledge, we called labour augment technology, while when capita is augment with the knowledge, called capital augment technology, thus the countries may sustained their output by the different combinations of labour augmenting and/or capital augmenting technology. The general form of Solow growth model is as follows:

$$Y_t = f(K_t, A_t \times L_t) \tag{ia}$$

$$Y_t = f(A_t \times K_t, L_t) \tag{ib}$$

where, 'Y' is the economic output, the product of $A \times L$ shows the technology and labor interaction, called labour augmenting technology, while the product of $A \times K$ shows the interaction of capital and technology, called capital augmenting technology. The functional relationship clearly explained that any combination of labor, capital and technology gives multiplier effect to produce output many times over a given period of time. One of the limitations of Equation (ia) and Equation (ib) is that Solow growth model does not included any environmental resource in growth matrix, as higher the combination of labor and capital resource exhausts the fixed environment resource, which have a detrimental impact on the quality of output. The presented study used Cobb-Douglas production function to include environmental factors in the growth accounting matrix to evaluate its impact on biodiversity loss in a panel of Asian countries. The equation of sustainability is shown in Equation (ii), i.e.,

$$B_t = AC_t^{\alpha}E_t^{\beta}\varepsilon_t \tag{ii}$$

where, 'B' shows biodiversity loss, 'A' is technology, 'C' is climate change, and 'E' is energy resources. The α and β shows constant return to scale, while ε shows error term.

Equation (ii) is simplified by taking natural log of both the sides, i.e.,

$$\ln B_{it} = \ln A_{it} + \alpha \ln C_{it} + \beta \ln E_{it} + \ln \varepsilon_{it} \tag{iii}$$

Differentiate with respect to 't' to obtained the growth rate of the following equation, i.e.,

$$\frac{1}{B_{it}}\frac{dB_{it}}{dt} = \frac{1}{A}\frac{dA_{it}}{dt} + \alpha\frac{1}{C}\frac{dC_{it}}{dt} + \beta\frac{1}{E}\frac{dE_{it}}{dt} + \frac{1}{\varepsilon}\frac{d\varepsilon_{it}}{dt} \tag{iv}$$

where, 'ln' is natural logarithm, 'i' is the cross-section identifier i.e., 'i' = 1 … …18 countries; 't' indicates time period i.e., 't' = 2000–2014, and ε indicates error term.

The study followed the scholarly work of [10,59–61]; to support our empirical equations in order to proposed an integrated environmental model to provoke sustainability agenda across Asian countries. The following form of equations is used to analyze the relationships between the candidate variables i.e.,

$$\begin{aligned} aquacpd_{it} = {} & \alpha_i + \beta_{i1} avgprcpt_{it} + \beta_{i2} co2_{it} + \beta_{i3} ghg_{it} + \beta_{i4} n2o_{it} \\ & + \beta_{i5} rec_{it} + \beta_{i6} rifr_{it} + \beta_{i7} fdi_{it} + \beta_{i8} gdp_{it} \\ & + \beta_{i9} popgr_{it} + \nu_i + \psi_t + \varepsilon_{it} \end{aligned} \tag{v}$$

$$\begin{aligned} farea_{it} = {} & \alpha_i + \beta_{i1} avgprcpt_{it} + \beta_{i2} co2_{it} + \beta_{i3} ghg_{it} + \beta_{i4} n2o_{it} \\ & + \beta_{i5} rec_{it} + \beta_{i6} rifr_{it} + \beta_{i7} fdi_{it} + \beta_{i8} gdp_{it} + \beta_{i9} popgr_{it} \\ & + \nu_i + \psi_t + \varepsilon_{it} \end{aligned} \tag{vi}$$

$$\begin{aligned} gef_{it} = {} & \alpha_i + \beta_{i1} avgprcpt_{it} + \beta_{i2} co2_{it} + \beta_{i3} ghg_{it} + \beta_{i4} n2o_{it} \\ & + \beta_{i5} rec_{it} + \beta_{i6} rifr_{it} + \beta_{i7} fdi_{it} + \beta_{i8} gdp_{it} + \beta_{i9} popgr_{it} + \nu_i \\ & + \psi_t + \varepsilon_{it} \end{aligned} \tag{vii}$$

$$\begin{aligned} tfishpd_{it} = {} & \alpha_i + \beta_{i1} avgprcpt_{it} + \beta_{i2} co2_{it} + \beta_{i3} ghg_{it} + \beta_{i4} n2o_{it} \\ & + \beta_{i5} rec_{it} + \beta_{i6} rifr_{it} + \beta_{i7} fdi_{it} + \beta_{i8} gdp_{it} + \beta_{i9} popgr_{it} \\ & + \nu_i + \psi_t + \varepsilon_{it} \end{aligned} \tag{viii}$$

where, ν_i shows country individual fixed effects, ψ_t shows time fixed effect, 'i' denotes the selected Asian countries (i = 1. …,18), 't' shows the time period (t = 2000–2014), and ε_{it} shows stochastic error term.

Equations (v)–(viii) evaluated by panel regression techniques and panel quantile regression. Panel regression techniques is fitted by 'Hausman test of model specification' that discriminate between panel fixed effect and panel random effect model to examine the impact of climate change and energy sources on biodiversity loss in a panel of countries. Panel regression technique is allowed to absorb the country specific time invariant shocks by including time dummies in a model. On the other hand, panel quantile regression analyzes the influencing variables that affect biodiversity loss in a low, medium and high quantile distribution. The study used three quantile distribution i.e., quantile distribution at 25% ($\tau_{0.25}$), quantile distribution at 50% ($\tau_{0.50}$), and quantile distribution at 75% ($\tau_{0.75}$). The low, medium, and high quantile distribution allow to assess the influencing variables that affect biodiversity loss at different percentiles, while it further address the trend deviation of panel regression estimates with the panel quantile regression. Cook-Weisberg test is used to check the Heteroskedasticity that would confirm the justification of quantile

regression to apply on the given set of variables in different prescribed studied models.

4. Data

The study examined different factors that influence biodiversity loss including climate change, energy sources, and growth specific factors at low-level, medium and high-levels i.e., 25th, 50th, and 75th quantile distribution, by using a consistent time series data from 2000 to 2014. The biodiversity factors include aquaculture production (metric tons), forest area (% of land area), GEF benefits index for biodiversity (0 = no biodiversity potential to 100 = maximum), and total fisheries production (metric tons); energy sources include nitrous oxide emissions in energy sector (thousand metric tons of CO2 equivalent), renewable energy consumption (% of total final energy consumption), and renewable internal freshwater resources per capita (cubic meters); growth specific factors include foreign direct investment net inflows (% of GDP), GDP per capita (constant 2005 US$), and population growth (annual %); and climate change factors include average precipitation in depth (mm per year), CO2 emissions (metric tons per capita), and total greenhouse gas emissions (kt of CO2 equivalent). The study selected the sample of 18 Asian countries such as Afghanistan (AFG), Bangladesh (BGD), Bhutan (BTN), Cambodia (KHM), China (CHN), India (IND), Indonesia (IDN), Japan (JPN), Jordan (JOR), Lao PDR (LAO), Malaysia (MYS), Nepal (NPL), Pakistan (PAK), Philippine (PHL), Singapore (SGP), Sri Lanka (LKA), Thailand (THA), and Vietnam (VNM) by using a consistent time series data from 2000 to 2014. The data of the variables are taken from World Development Indicators published by World Bank [62]. The missing data is filled with interpolation technique for robust inferences. Figure-A in Appendix –I shows the plots of level data and indicated the trend analysis of the selected variables during the period of 2000–2014 in a panel of 18 selected Asian countries. The aquaculture production, per capita income, GEF benefits biodiversity index, N2O emissions, total fisheries production, and renewable internal fresh water resources have a swift inclination during some specified time period, however, after that, the data series proceed for the consistent movement across countries. The remaining variables tend to show the fluctuations in the data series during the given period of time across countries.

It is evident that Asian countries face severe environmental concerns that affect country's economic growth in the long-run [63]. Climatic factors affect not only sectoral growth that deteriorate country's overall economic growth while it's affect the countries natural flora including changes in the ecosystems and biodiversity loss. According to Squires [64]; p. 144), *"Asian's remarkable economic growth brought many benefits but also fuelled threats to its ecosystems and biodiversity. Economic growth brings biodiversity threats but also conservation opportunities"*. These factors previously examined in relation with the per capita income of the countries, while in this study, we find its impact on biodiversity loss, which would facilitate the policy makers and environmentalist to formulate biodiversity conservation policies in order to meet the United Nations –Kyoto protocol for environmental sustainability across the globe. Figure-A plots the level data and presented in Appendix for ready reference.

These variables are selected on the basis of their strong appearance in the previously cited literature, which provoked the need of an integrated environmental model, which helpful to device strong policy vista for optimizing the resources without sacrificing the future generation needs and devoted resources for healthy and sustainable environment. The study used following variables in this study, i.e.,

i) **Climate Change**: Climate change is attributed due to high rising sea level, extreme weather events and unpredictable weather changes. Human activities are the driving force to raise greenhouse gas (GHG) emissions, which changes the climatic situation. The main GHG emissions are carbon emissions, methane emissions, nitrous oxide emissions, and fluorinated gases. Carbon dioxide emissions produced 72% of GHG emissions followed by methane emissions by 18%, and nitrous oxide emissions by 9%. Thus, carbon emissions are considered one of the major sources of climate change, which is inevitably created by burning fossil fuels [65]. The average precipitation is used as a proxy measure for climate change. One of the possible reasons is that global warming directly influences the precipitation, i.e., increased heating leads to an increase greater evaporation, which ultimately increase the intensity of drought [66], thus it affects global biodiversity.

ii) **Renewable Energy**: The importance of renewable energy in sustainable development is imperative for sound economic growth. The study used three main renewable energy sources, including renewable energy consumption, nitrous oxide emissions from energy sector and renewable internal fresh water resources. Renewable energy consumption helpful to reduce substantial amount of GHG emissions and it reduces combustion of burning fossil fuels [67]. Nitrous oxide emissions considered the global pollutant and it is used here for linking with the green economy by sustainable mode of energy resources [68]. The study used renewable internal fresh water resources instead of 'water pollution' due to two main reasons, first, fresh water resources linked with the sustainable development [69], secondly, it is imperative to reduce global crisis of water and energy supply by renewable fresh water resources, which is impaired water resources by desalination [70].

iii) **Biodiversity Loss**: The United Nation Conservation of biological diversity is the paramount concern for reducing biodiversity loss by sustainable development policy actions [71]. This study used four variables for conservation biodiversity, i.e., aquaculture production, forest area (proxy variable for potential habitat area), GEF benefits index for biodiversity, and total fisheries production. These factors selected because climate change and loss of potential habitat area both threatened to the natural system and biodiversity, which required efficient conservation management strategies for sustainable development [72]. For sound aquaculture production practices, it is necessary to reduce wild fish supplies as inputs in feed to carnivorous species and adds world fish supplier [73], which support biological diversity convention by United Nations.

Appendix –II shows the some functional relationships between biodiversity factors, climate change, and energy resource factors from Equations (1)–(4) and hypothesize that climatic factors, including average precipitation, CO2 emissions, GHG emissions, and N2O emissions will expected to hurt biodiversity agenda in the form of decrease aquaculture production, loss of natural habitat area in the form of forest area depletion, loss of GEF benefits biodiversity index, and decline in total fisheries production, whereas, renewable energy consumption and internal fresh water resource will expected to support biodiversity factors across countries. The economic factors, including FDI inflows, per capita income, and population growth may have differential impacts on biodiversity in a panel of selected Asian countries.

Fig. 1 shows the trend analysis of biodiversity factors at different quantiles and illustrates that aquaculture production (Fig. 1 a) tend

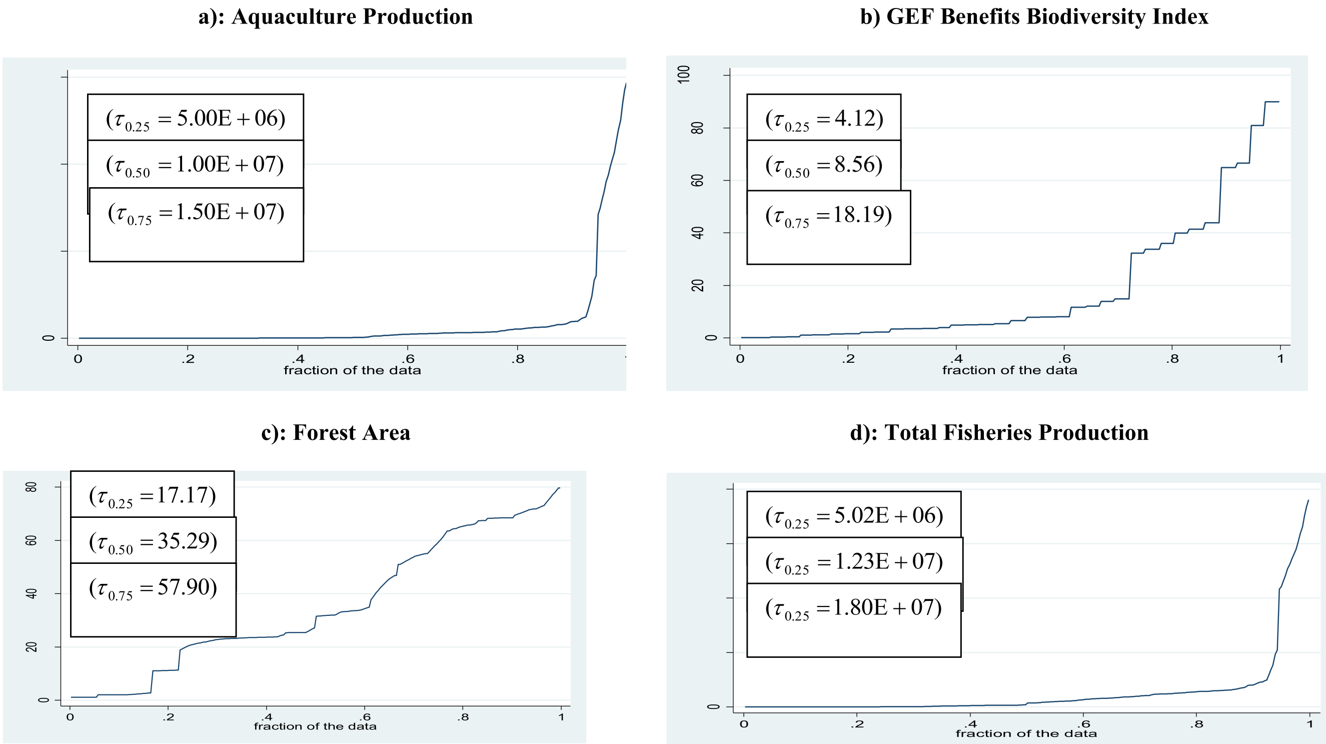


Fig. 1. Plots of quantile data for the dependent variables.
Source: Authors' estimation by using the data from World Bank [62]. AQUACPD indicates aquaculture production, GEF indicates GEF benefits biodiversity index, FAREA indicates forest area, and TFISHPD indicates total fisheries production.

to exhibit a constant growth in metric tons from 1st quantile to 90th quantile, however, after 90th quantile, its distribution tend to increase with increasing rate. The data series of forest area (Fig. 1 b) are highly volatile at different quantile levels, at first it increasing with the steady rate till 20th quantile, than it moves faster and grow with an increasing rate till 90th quantile and crosses 80% of total land area.

The GEF biodiversity index (Fig. 1 c) has a steady growth rate till 60th quantile, while it speed up and considerably increases in the next subsequent quantiles and reached the index value around 80 which shows the potential of biodiversity exist in the panel of countries. Finally, the total fisheries production (Fig. 1d) constantly increase till 60th quantile, after that it's slightly increases till 80th quantile and gaining the pace after 80th quantile. Fig. 1 clearly shows the wide fluctuations in the biodiversity factors at different quantile distribution, therefore, it is necessary to analyze the impact on biodiversity factors by climate change, energy sources, and growth specific effects at low, medium and high-levels quantile distribution.

5. Results and discussions

Table-A in Appendix iii shows the descriptive statistics and correlation matrix for the ready reference. The mean value of aquaculture production has a minimum value of 30 metric tons and maximum value of 58797258 metric tons with an average value of 3253972 metric tons. The average value of average precipitation is about 1667.167 mm per year with a maximum precipitation is 2875 mm per year. The minimum value of carbon dioxide emissions is 0.031 metric tons per capita and a maximum value of 12.166 metric tons per capita with an average value of 2.451 metric tons per capita. The average value of forest area is about 35.214% of land area with a standard deviation of 24.162% of land area have a positive skewed distribution with reasonable peak of the distribution. The average value of FDI inflow is 3.416% of GDP with positive skewed distribution. The minimum value of GDP per capita is 239.699 US$ and a maximum value of 38087.66 US$ with an average value of 5062.963 US$. The average value of total greenhouse gas emissions is about 18.306 kt of CO2 equivalent. The minimum value of nitrous oxide emissions is 51.324 thousand tons of CO2 equivalent and a maximum value of 52936.03 with an average value of 5255.933 thousand tons of CO2 equivalent. The maximum value of population growth is 5.321% with an average value of 1.530%. The average value of renewable energy consumption, renewable internal fresh water resources, and total fisheries production is about 41.624% of total energy consumption, 12004.43 cubic meters per capita, and 5464002 metric tons respectively.

Table –A, Appendix III, panel –B shows that there is a negative correlation of aquaculture production with average precipitation FDI inflows, GDP per capita income, population growth, renewable energy consumption, and renewable internal fresh water resources, while it has a positive correlation with the carbon dioxide emissions, GHG emissions, and nitrous oxide emissions in a panel of selected Asian countries. The forest area has a positive correlation with the average precipitation, carbon dioxide emissions, and GDP per capita, while it has a negative correlation with the FDI inflows, GHG emissions, nitrous oxide emissions, population growth, renewable energy consumption and renewable internal fresh water resources. The biodiversity benefits index has a positive correlation with the climate change variables, while it has a differential impact with energy sources, and growth specific factors in a panel of countries. The total fisheries production has a negative correlation with the average precipitation, FDI inflows, GDP per capita, population growth, renewable energy consumption, and renewable internal fresh water

Table 2
Hausman test for model specification.

Test Summary for the Biodiversity Factors	Chi-square statistics	Decision
AQUACPD	104.664*	Fixed Effect Model is best fitted model as compared to random effect model
FAREA	15.751**	Fixed Effect Model is best fitted model as compared to random effect model
GEF	35.717*	Fixed Effect Model is best fitted model as compared to random effect model
TFISHPD	127.982*	Fixed Effect Model is best fitted model as compared to random effect model

Note: AQUACPD indicates aquaculture production, FAREA indicates forest area, GEF indicates GEF benefit index of biodiversity, and TFISHPD indicates total fisheries production. * and ** indicates 1% and 5% level of significance.

resources, while it has a positive correlation with the carbon dioxide emissions, GHG emissions, and nitrous oxide emissions. The correlation results further checked by panel regression apparatus in a panel of selected Asian countries.

Before we estimates the panel regression, the study employed Hausman test for model specifications and compare the panel fixed effect and panel random effect models in the biodiversity factors. Table 2 shows the Hausman test for model specifications and found the significance of chi-square statistics at 5% in all four biodiversity factors.

Table 2 shows that aquaculture production has a significant chi-square statistics that confirm the existence of country-specific-time-invariant shocks in a given biodiversity factors. Similarly, the other biodiversity factors including forest area, GEF benefits index of biodiversity and total fisheries production all have a significant chi-square statistics value, therefore, the study discriminate panel fixed effect model as compared to the panel random effect model. After the selection of appropriate panel technique, the study estimates the coefficient by panel fixed effect regression and panel quantile regression at low, medium, and high-levels quantile distribution to assess the intensity and magnitude variations for the explanatory variables affecting biodiversity factors at 25th quantile, 50th quantile, and at 75th quantile. Table 3 shows the estimates of panel fixed effect regression and panel quantile regression for aquaculture production in a panel of Asian countries.

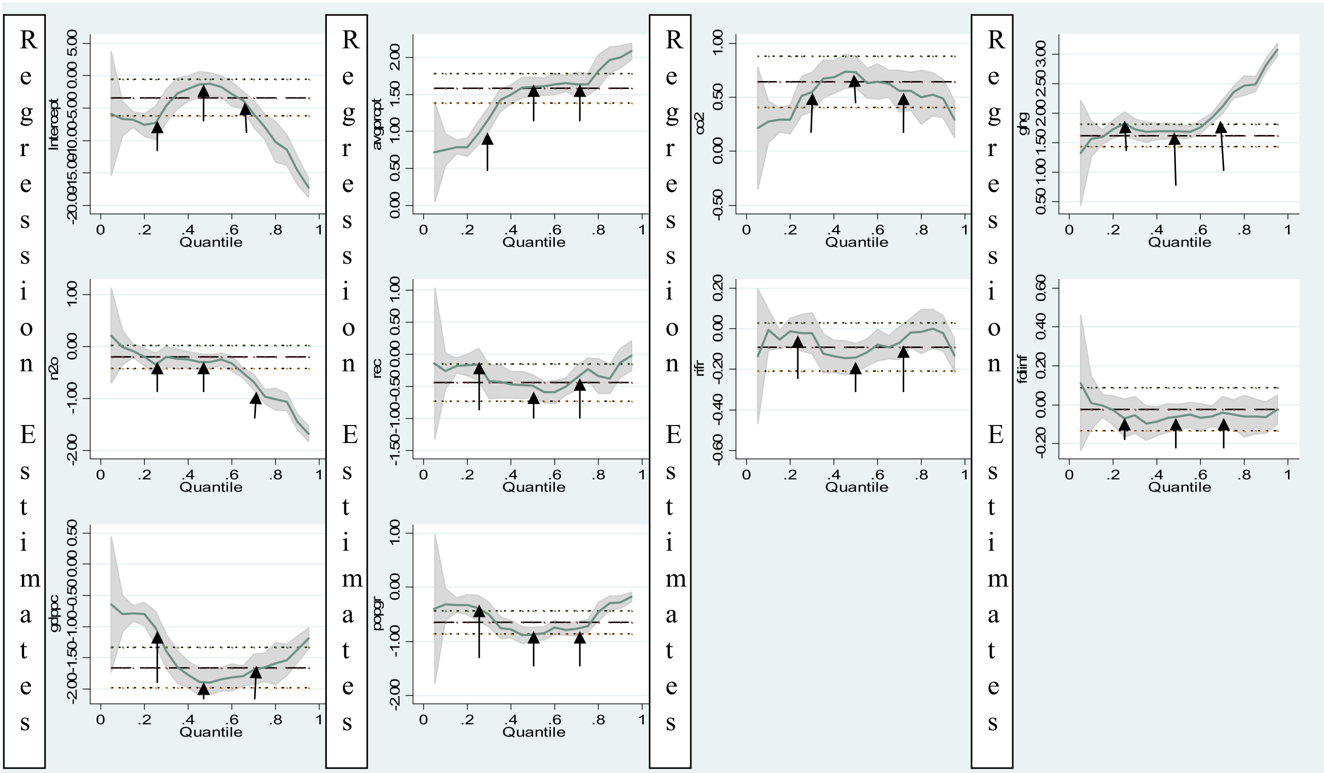
The results show that climatic factors including average precipitation and carbon dioxide emissions both significantly affected the aquaculture production, while the impact of GHG emissions does not significantly explained its impact on aquaculture production during the study time period. The results reveal that average precipitation has a more elastic relationship with the aquaculture production as the elasticity value of the coefficient estimate exceeds the value of unity, while carbon dioxide emissions has a less elastic relationship with the aquaculture production. Energy sources has a differential impact on aquaculture production, as nitrous oxide emissions of energy sector and renewable energy consumption both has a positive and significant impact on aquaculture production while renewable internal fresh water resources has a negative correlation with the aquaculture production. The results further simplify that the impact of nitrous oxide emissions and renewable energy consumption on increasing aquaculture production is greater than the impact of decreasing aquaculture production by renewable internal fresh water, as the elasticity estimates for nitrous oxide emissions (1.023, $p < 0.01$) are more elastic, renewable energy consumption estimates are less elastic (0.655, $p < 0.01$), and renewable internal fresh water resources are negative and less elastic relationship (−0.527, $p < 0.01$) with aquaculture production in a panel of countries. The growth specific factors including FDI inflows and per capita income both has a positive and significant impact on aquaculture production, however, per capita income has a greater magnitude in terms of affecting aquaculture production as compared to FDI inflows cross countries. Population growth does not explain its significant impact on aquaculture production during the study time period.

The results of panel quantile regression confirm the strong and positive correlation between climate change factors and aquaculture production with greater magnitude in different quantile distribution as compared to the panel fixed effect regression

Table 3
Panel fixed effect and panel quantile regression for aquaculture production.

Variables	Panel Fixed Effect	Panel Quantile Regression		
		Quantile regression at 25% ($\tau_{0.25}$)	Quantile regression at 50% ($\tau_{0.50}$)	Quantile regression at 75% ($\tau_{0.75}$)
Constant	−8.625*	−7.281*	1.283	−7.939*
ln (AVGPRCPT)	1.334*	0.978*	1.602*	1.132*
ln (CO2)	0.565*	0.509*	0.733*	0.557*
ln (GHG)	0.118	1.826*	1.693*	2.360*
ln (N2O)	1.023*	−0.338*	−0.290*	−0.963*
ln (REC)	0.655*	−0.158	−0.494*	−0.233*
ln (RIFR)	−0.527*	−0.021	−0.143*	−0.020
Ln (FDI)	0.048**	−0.068	−0.060***	−0.040
ln (GDP)	0.586*	−1.025*	−1.903*	−1.650***
ln (POPGR)	0.010	−0.389*	−0.868*	−0.714*
Statistical Tests				
R-squared	0.584	–	–	–
Adjusted R-squared	0.569	–	–	–
Pseudo R-square	–	0.779	0.773	0.723
F-statistic	38.364*	–	–	–
Breusch-Pagan/Cook-Weisberg test for Heteroskedasticity: Chi-square value (degree of freedom-9): 48.13*				

Note: AQUACPD indicates aquaculture production, AVGPRCPT indicates average precipitation, CO2 indicates carbon dioxide emissions, FAREA indicates forest area, FDI indicates Foreign Direct Investment inflows, GDP indicates per capita GDP, GEF indicates GEF benefits biodiversity index, GHG indicates Greenhouse Gas emissions, N2O indicates nitrous oxide emissions, POPGR indicates population growth, REC indicates renewable energy consumption, RIFR indicates renewable internal fresh water resources, and TFISHPD indicates total fisheries production. *, **, and *** indicates 1%, 5%, and 10% significance level.



Note: AVGPRCPT indicates average precipitation, CO2 indicates carbon dioxide emissions, FDI indicates Foreign Direct Investment inflows, GDP indicates per capita GDP, GHG indicates Greenhouse Gas emissions, N2O indicates nitrous oxide emissions, POPGR indicates population growth, REC indicates renewable energy consumption, and RIFR indicates renewable internal fresh water resources. The upward arrows show 0.25, 0.50, and 0.75th quantile distribution.

Fig. 2. Quantile regression estimates of aquaculture production.

estimates. The impact of GHG emissions shows a positive and more elastic relationship with the aquaculture production in different quantile distribution, which was previously absent in the panel fixed effect regression. The panel quantile regression results in terms of energy resources are quite dissimilar with the estimates of panel fixed effect regression at different quantile distribution, as 25th quantile, the impact of nitrous oxide emissions is significant and negative on aquaculture production, while at 50th quantile and 75th quantile, the results tend to show the negative and significant impact of nitrous oxide emissions on aquaculture production. This dissimilar result we may easily seen in Fig. 2 where the quantile estimates of nitrous oxide emissions fairly dissimilar with the panel regression estimates and tend to decrease sharply against the panel regression estimates. Fig. 2 illustration of GHG emissions shows that panel fixed effect does not captured its significant impact on aquaculture production while in quantile regression, we may fairly observe that the estimates of GHG emissions at different quantiles tend to sharply increase against the panel fixed effect estimates. Similarly, we find the estimates of renewable energy consumption at different quantile regression that tend to show the negative and significant impact on aquaculture production, while the panel fixed effect estimates show the positive correlation between renewable energy consumption and aquaculture production. We may assess the trend magnitude of panel quantile regression against the panel fixed effect regression in Fig. 2 where the quantile regression estimates are fairly have a disjoint trend against the panel fixed effect regression estimates.

The overall results conclude that fisheries and aquaculture production both affected by climate change, as fisheries and aquaculture provides food to the country's resident and reduces the challenges of food insecurity, and it uses as export items in many developing countries. The threat to climate change not only affects the biodiversity loss, while its affect the production of fishers and aquaculture production across the globe [74]. Climate change largely affects the food webs, species habitats area and stocks of fisheries and aquaculture, which impose serious economic, environmental and social issues across the region [75]. It is evident that as global population increases, its demand for fisheries and aquaculture production many times increases, thus the policy intervention is required to reduce climatic variability by sustainable modes of production and consumption to prevent this sector from unwanted climatic effects [76].

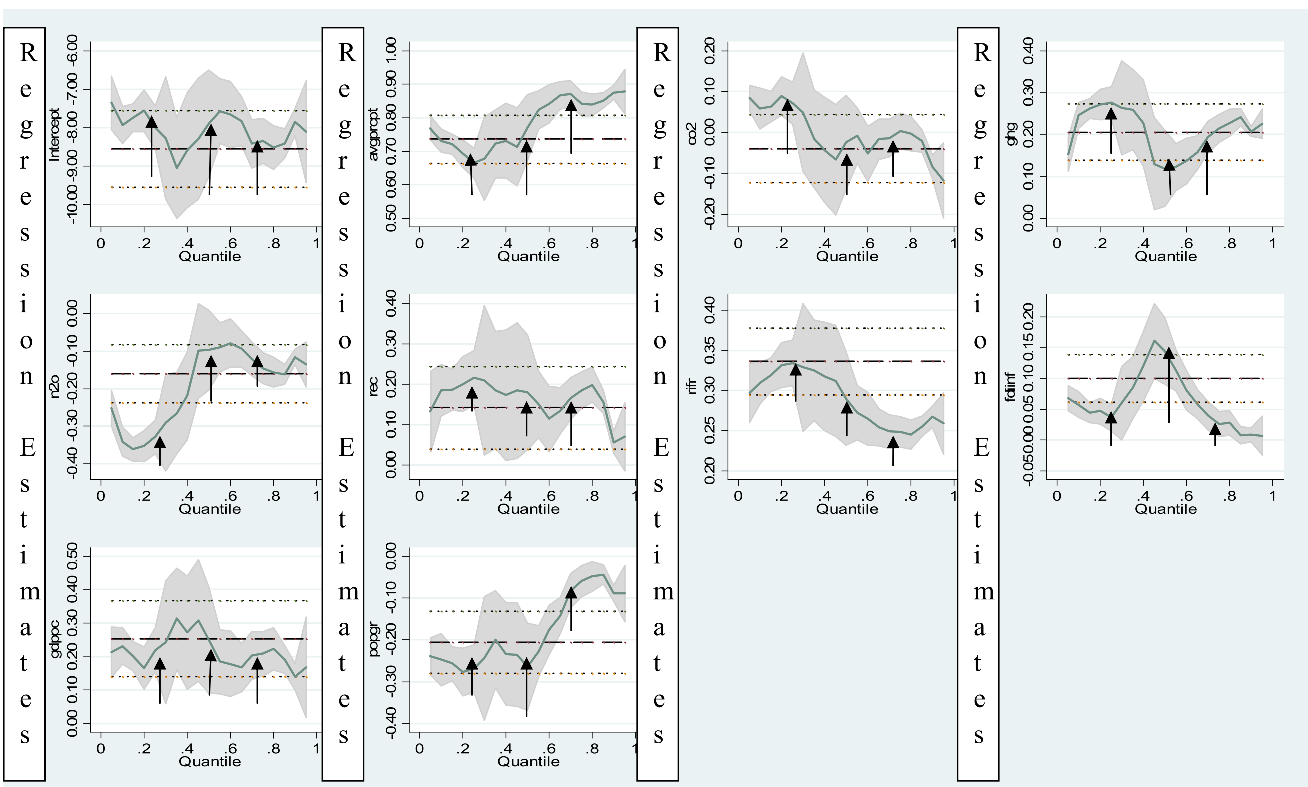
The differences of the results in terms of variable's significance, magnitude and direction in both the panel estimation is that panel fixed effect captured overall impact of the explanatory variables on the ‘response variable’ while it ignores the variables deviation on different quantiles, which is desirable to see the deviation of explanatory factors on the ‘response’ variable (by panel quantile regression) for robust inferences. Fig. 2 shows the fluctuation of parameter estimates of growth specific variables as compared to the panel fixed effect regression, which further verified in the Breusch-Pagan/Cook-Weisberg test for Heteroskedasticity, as the significant chi-square value indicates the existence of unequal variance in the given variables at different quantile distribution as compared to the panel regression. Fig. 2 shows the quantile regression estimate for aquaculture production for the ready reference.

Table 4 shows the estimates of panel fixed effect and panel

Table 4
Panel fixed effect and panel quantile regression for forest area.

Variables	Panel Fixed Effect	Panel Quantile Regression		
		Quantile regression at 25% ($\tau_{0.25}$)	Quantile regression at 50% ($\tau_{0.50}$)	Quantile regression at 75% ($\tau_{0.75}$)
Constant	−6.732*	−7.998*	−7.890*	−8.346*
log (AVGPRCPT)	0.913*	0.664*	0.770*	0.840*
log (CO2)	−0.021	0.072*	−0.023	0.003
log (GHG)	0.022**	0.275*	0.118*	0.214*
log (N2O)	0.025	−0.328*	−0.096***	−0.145*
log (REC)	−0.058**	0.216*	0.180**	0.186*
log (RIFR)	0.304*	0.334*	0.289*	0.248*
log (FDI)	0.002	0.036*	0.144*	0.026**
log (GDP)	0.076*	0.220*	0.249*	0.208*
log (POPGR)	−0.002	−0.268*	−0.264*	−0.059*
Statistical Tests				
R-squared	0.448	–	–	–
Adjusted R-squared	0.428	–	–	–
Pseudo R-square	–	0.775	0.687	0.686
F-statistic	22.148*	–	–	–
Breusch-Pagan/Cook-Weisberg test for Heteroskedasticity: Chi-square value (degree of freedom-9): 83.83*				

Note: AQUACPD indicates aquaculture production, AVGPRCPT indicates average precipitation, CO2 indicates carbon dioxide emissions, FAREA indicates forest area, FDI indicates Foreign Direct Investment inflows, GDP indicates per capita GDP, GEF indicates GEF benefits biodiversity index, GHG indicates Greenhouse Gas emissions, N2O indicates nitrous oxide emissions, PPOPGR indicates population growth, REC indicates renewable energy consumption, RIFR indicates renewable internal fresh water resources, and TFISHPD indicates total fisheries production. *, **, and *** indicates 1%, 5%, and 10% significance level.



Note: AVGPRCPT indicates average precipitation, CO2 indicates carbon dioxide emissions, FDI indicates Foreign Direct Investment inflows, GDP indicates per capita GDP, GHG indicates Greenhouse Gas emissions, N2O indicates nitrous oxide emissions, POPGR indicates population growth, REC indicates renewable energy consumption, and RIFR indicates renewable internal fresh water resources. The upward arrows show 0.25, 0.50, and 0.75th quantile distribution.

Fig. 3. Quantile regression estimates of forest area.

quantile regression for forest area. The results show that average precipitation has a significant and positive impact on forest area which is subsequently increases the estimated values with different quantiles distribution. The impact of carbon dioxide emissions does not explain its significant impact on forest area by using panel fixed effect regression, while at 25th quantile it shows a significant association with forest area in a panel of countries.

The relationship between GHG emissions and forest area is positive by using panel fixed effect regression and similar results have been obtained from panel quantile distribution with greater

magnitude power. Fig. 3 clearly shows the high volatility of coefficient estimates that swing upward and downward at 25th quantile, 50th quantile, and at 75th quantile as compared to the panel fixed effect. The impact of nitrous oxide emissions on forest area is insignificant, while at different panel quantile distributions, it is clearly evident that the impact of nitrous oxide emissions on forest area is negative and significant with high and low magnitude powers. This trend we may clearly observe in panel quantile regression in Fig. 3 where the left hand side tail of 25th quantile is increasing sharply till 40th quantile and latterly it increases with decreasing rate after 40th quantile. The relationship between renewable energy consumption and forest area is indirect with a coefficient value of −0.058, $p < 0.05$, however, this result is disappeared in panel quantile regression that shows positive association between both of the variables i.e., at 25th quantile the estimated value is 0.216, $p < 0.010$; at 50th quantile the estimated value is 0.180, $p < 0.050$; and at 75th quantile the estimated value is about 0.186, $p < 0.010$. There is a significant and positive relationship between renewable internal fresh water resources and forest area by using both the panel fixed effect and panel quantile regression. FDI inflows do not tend to show its significant impact on forest area, however, panel quantile regression trace out the positive association between the two variables. We may see the symmetric direction of FDI inflows with different quantile distributions in Fig. 3 that increases sharply from 20th quantile to 40th quantile, while it falling down sharply after 40th quantile. GDP per capita shows the positive association with the forest area by using both the panel fixed effect regression and panel quantile regression; however, quantile distributions have a greater magnitude in terms of increasing forest area as compared to panel fixed effect regression. Finally, population growth does not explain its significant impact on forest area in panel fixed effect regression, while panel quantile regression shows negative association between the two variables. We may see in Fig. 3 that population growth sharply increases after 40th quantile with increasing rate.

The overall results imply that destruction of forest area and climate change both are the serious threat to the global biological diversity [77]. Over a period of time, climatic variability alter the nature, distribution and abundance of species; hence it is desirable to implement less carbon policies that helpful to mitigate GHG emissions to sustained biodiversity across countries [78]. It is worth noted that climatic variability although benefited for some biodiversity, however, ocean acidification seriously affect the aquaculture production, shellfish fisheries and other potential species. Extreme temperature poses serious infections to human health, tourists' arrival, tourism revenues, and coastal infrastructure and its repairment. It is imperative to developed coastal infrastructure to reduce the risks of climatic vulnerability and biodiversity loss [79]. Fig. 3 here is presented for the ready reference.

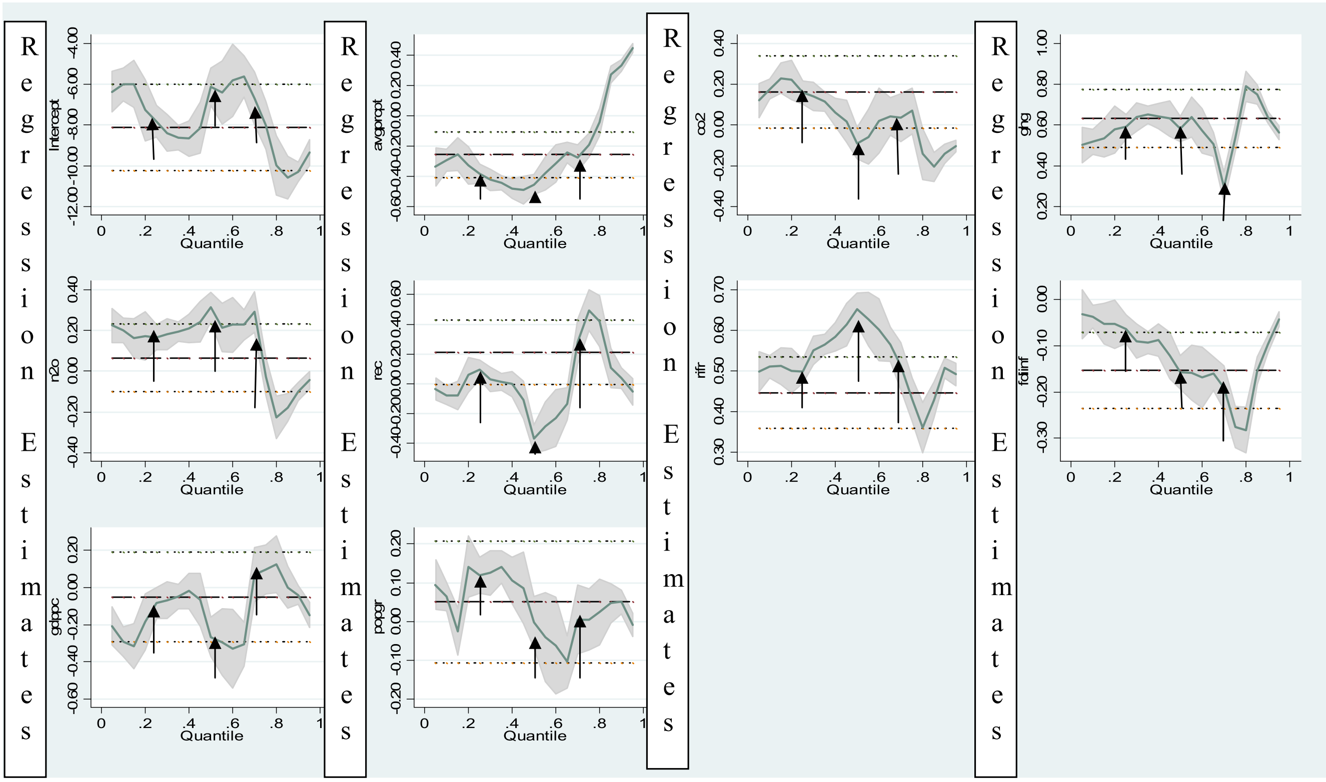
Table 5 shows the results of panel fixed effect and panel quantile regression for GEF benefits index of biodiversity. The results show that average precipitation has a negative and significant relationship with the GEF biodiversity index at low, medium and high levels quantile distribution. Carbon dioxide emissions has a positive correlation with the GEF biodiversity index by using panel fixed effect regression, while at 50th quantile this relationship turns to become negative with the carbon emissions. This relationship we may see in Fig. 4 where carbon dioxide emissions tend to decrease it from 20th quantile to 50th quantile, after that it begins to rise and then falls subsequently.

The relationship between GHG emissions and GEF benefits biodiversity index is direct and significant at different quantile distributions while this relationship is not present by using panel fixed effect regression. In Fig. 4, we may see that there is a straight decline in the GHG emissions from 60th quantile to 70th quantile, then again it swings upward and then downwards in the later quantiles. Nitrous oxide emissions has a positive association with the GEF benefits biodiversity index at 25th quantile and at 50th quantile while in remaining quantile distributions and panel fixed effect regression does not explain its significant impact with GEF biodiversity index. Renewable energy consumption has a significant and positive association with the GEF biodiversity index by using panel regression and panel quantile distribution at 25th quantile and 75th quantile; however, it shows an indirect relationship at 50th quantile. Fig. 4 shows that the quantile deviations at 20th percentile to 50th percentile considerably decline, and then it increasing up to 80th percentile and again decreasing in next subsequent quantiles. The impact of fresh water resources

Table 5
Panel fixed effect and panel quantile regression for GEF biodiversity.

Variables	Panel Fixed Effect	Panel Quantile Regression		
		Quantile regression at 25% ($\tau_{0.25}$)	Quantile regression at 50% ($\tau_{0.50}$)	Quantile regression at 75% ($\tau_{0.75}$)
Constant	−1.838	−7.820*	−6.133*	−8.031*
log (AVGPRCPT)	0.177	−0.382*	−0.454*	−0.193*
log (CO2)	0.085*	0.159*	−0.089**	0.069
log (GHG)	0.013	0.591*	0.581*	0.539*
log (N2O)	0.050	0.166*	0.313*	−0.025
log (REC)	0.177*	0.094*	−0.370*	0.495*
log (RIFR)	0.171*	0.498*	0.652*	0.429*
log (FDI)	−0.004	−0.063*	−0.157*	−0.276*
log (GDP)	−0.008	−0.082***	−0.265*	0.096
log (POPGR)	0.021*	0.120*	−0.002	0.005
Statistical Tests				
R-squared	0.261	–	–	–
Adjusted R-squared	0.234	–	–	–
Pseudo R-square	–	0.701	0.616	0.569
F-statistic	9.642*	–	–	–
Breusch-Pagan/Cook-Weisberg test for Heteroskedasticity: Chi-square value (degree of freedom-9): 61.09*				

Note: AQUACPD indicates aquaculture production, AVGPRCPT indicates average precipitation, CO2 indicates carbon dioxide emissions, FAREA indicates forest area, FDI indicates Foreign Direct Investment inflows, GDP indicates per capita GDP, GEF indicates GEF benefits biodiversity index, GHG indicates Greenhouse Gas emissions, N2O indicates nitrous oxide emissions, PPOPGR indicates population growth, REC indicates renewable energy consumption, RIFR indicates renewable internal fresh water resources, and TFISHPD indicates total fisheries production. *, **, and *** indicates 1%, 5%, and 10% significance level.



Note: AVGPRCPT indicates average precipitation, CO2 indicates carbon dioxide emissions, FDI indicates Foreign Direct Investment inflows, GDP indicates per capita GDP, GHG indicates Greenhouse Gas emissions, N2O indicates nitrous oxide emissions, POPGR indicates population growth, REC indicates renewable energy consumption, and RIFR indicates renewable internal fresh water resources. The upward arrows show 0.25, 0.50, and 0.75th quantile distribution.

Fig. 4. Quantile Regression Estimates of GEF Benefits index of Biodiversity.

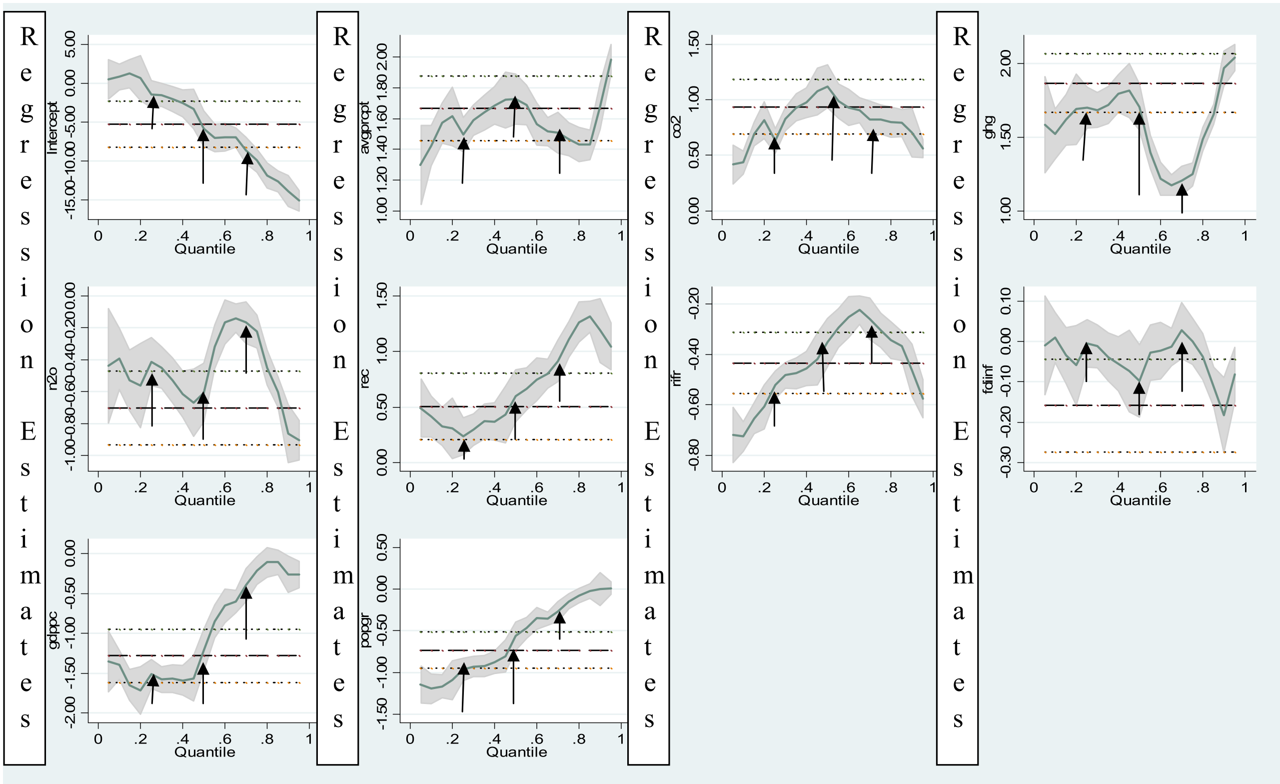
Table 6
Panel fixed effect and panel quantile regression for total fisheries production.

Variables	Panel Fixed Effect	Panel Quantile Regression		
		Quantile regression at 25% ($\tau_{0.25}$)	Quantile regression at 50% ($\tau_{0.50}$)	Quantile regression at 75% ($\tau_{0.75}$)
Constant	−3.300	−1.460	−5.894*	−9.963*
ln (AVGPRCPT)	1.360*	1.494*	1.726*	1.465*
ln (CO2)	0.358*	0.631*	1.119*	0.823*
ln (GHG)	0.082***	1.698*	1.704*	1.247*
ln (N2O)	0.629*	−0.411*	−0.605*	−0.224*
ln (REC)	0.316*	0.236*	0.599*	1.105*
ln (RIFR)	−0.191	−0.520*	−0.351*	−0.303*
ln (FDI)	0.010	−0.004	−0.097**	0.0001
ln (GDP)	0.197**	−1.510*	−1.211*	−0.213**
ln (POPGR)	0.086**	−0.961*	−0.561*	−0.149*
Statistical Tests				
R-squared	0.444	–	–	–
Adjusted R-squared	0.423	–	–	–
Pseudo R-square	–	0.790	0.736	0.704
F-statistic	21.751*	–	–	–
Breusch-Pagan/Cook-Weisberg test for Heteroskedasticity: Chi-square value (degree of freedom-9): 79.30*				

Note: AQUACPD indicates aquaculture production, AVGPRCPT indicates average precipitation, CO2 indicates carbon dioxide emissions, FAREA indicates forest area, FDI indicates Foreign Direct Investment inflows, GDP indicates per capita GDP, GEF indicates GEF benefits biodiversity index, GHG indicates Greenhouse Gas emissions, N2O indicates nitrous oxide emissions, PPOPGR indicates population growth, REC indicates renewable energy consumption, RIFR indicates renewable internal fresh water resources, and TFISHPD indicates total fisheries production. *, **, and *** indicates 1%, 5%, and 10% significance level.

significantly increases the potential of biodiversity potential in a panel of countries. FDI inflows and per capita income both has a negative impact on the potential of biodiversity whereas population growth increases the potential of biodiversity across countries.

The overall results concluded that increase reforestation and reducing deforestation both are the policy matters to sustained the two international agreements, i.e., one is for reducing carbon emissions as per United Nations Kyoto protocol and second is to reduce biodiversity loss as per the binding agreement of



Note: AVGPRCPT indicates average precipitation, CO2 indicates carbon dioxide emissions, FDI indicates Foreign Direct Investment inflows, GDP indicates per capita GDP, GHG indicates Greenhouse Gas emissions, N2O indicates nitrous oxide emissions, POPGR indicates population growth, REC indicates renewable energy consumption, and RIFR indicates renewable internal fresh water resources. The upward arrows show 0.25, 0.50, and 0.75th quantile distribution.

Fig. 5. Qunatile regression estimates of total Fosheries production.

convention on biological diversity. The reduction of deforestation is helpful to mitigate climatic variations than converting forest for biofuel production, which helpful to reduce global biodiversity [80]. The renewable energy resources are one of the mitigating climatic factors that helpful to reduce biodiversity loss [26], while its environmental impact further improve air quality indicators, soil chemistry, landscape value, human health, and domestic economies [81]. Fig. 4 shows the quantile regression estimates of GEF benefits index of biodiversity for ready reference.

Table 6 shows the estimate of total fisheries production in relation with climate change, energy resources, and growth specific factors in a panel of selected Asian countries. The results show that average precipitation, carbon dioxide emissions, and GHG emissions all the three factors of climate change has exerted the positive and significant impact on total fisheries production by using both the panel fixed effect regression and panel quantile regression. The relationship between nitrous oxide emissions and total fisheries production is direct by using panel fixed effect regression, however, this result is evaporated while using panel quantile regression, as it shows negative correlation between nitrous oxide emissions and total fisheries at low, medium and high levels quantile distribution.

Fig. 5 shows the disproportional trend series of the growth specific variables in relation with total fisheries production that surpasses the actual trend line of panel regression. The figure illustrated that from 40th quantile to 60th quantile, the series of nitrous oxide emissions drastically go upward trend that surpasses the estimates of panel fixed effect regression, and afterward it tends to decrease in subsequent quantiles. The renewable fresh water resources decrease the total fisheries production at different quantiles; however, this relationship is insignificant by using panel fixed effect regression. Growth specific factors tend to show a negative correlation with the total fisheries production at different quantile regression, while GDP per capita and population growth exhibit a positive relationship with total fisheries production by using a panel regression.

The overall results argued that climatic uncertainty largely influenced the global fisheries production and aquaculture production in the form of distribution and size of the fishes, while inland fisheries further threatened by changes in water management and changes in average precipitation. Thus, it is important to conserve our fisheries production by sound climate change management to support both inland and marine systems [82].

6. Policy analysis

The results of the study linked with the previous studies in order to discuss the environmental sustainable policies for conservation of biodiversity and natural resources by mediating renewable energy sources and economic interventions to mitigate GHG emissions and carbon emissions across the globe. Climate change affects agricultural commodities, energy demand, health related problems, weather, extreme temperature, rising sea level, and many nature of environmental problems including ecosystem and biodiversity loss. Greenhouse gas emission is the volatile factor to increase air pollutants and carbon emissions that are the

main hurdle to achieve the green environment across the globe [83]. Convention on biological diversity is one of the policy wish to reduce and/or diminish the possible rate of global biodiversity loss, however, it's received a very few local based success stories. There is no such overwhelming affect has been observed to categorize that globally we are on the right track to conserve biodiversity loss across countries [84].

There are number of mechanized way to assess the different channels that affect the biodiversity loss, among them two channels have a considerable impact on biodiversity loss i.e., reduction in the plant production by 5%–10% increases the ecological animal and plant species loss around 21%–40%, while some other factors including ozone depletion, acid rain fall, concentration of carbon emissions in the atmosphere and nutrient pollution largely affected the biodiversity loss around 41%–60%. These statistics provide a food-for-thought for the environmentalist and conservation biologist to reduce the species loss by increasing forestation, plantation, and controlling environmental factors for conservation of biodiversity loss [85]. Climatic variations, if not mitigated, would caused greater destruction in terms of ecological animal species loss of about 34 ± 7% and plant species loss of about 57 ± 6% by 2080s, while if climatic variations properly treated it would reduce up to 40%–60% total biodiversity loss [13]. Freshwater ecosystem also affected by land use management and climate change that need strategic policy actions to conserve fisheries production and macroinvertebrate [86]. Eisner et al. (2016, p. 147) concluded that, "… … *conservation efforts need to mitigate pressures from growth and agricultural extensification, and be aware that the rate of loss increased with oil supply constraint in tropical and sub-tropical regions, coinciding with the areas of highest biodiversity*".

The policy analysis caters the need to device long-term environmental sustainable policies to preserve our natural habitat base that could be possible, if and only if, we given priority to our environment, and formulate economic and environmental policies to conserve our biodiversity loss through appropriate renewable energy mix and balancing the economic factors for green growth.

7. Conclusions

The goal is to study the impact of a given set of variables on biodiversity loss under conditional distribution at 25th quantile, 50th quantile, and 75th quantile in a panel of selected Asian countries, over a period of 2000–2014. The study used three factors of climate change including average precipitation, CO_2 emissions, and GHG emissions; three factors of energy sources including nitrous oxide emissions of energy sector, renewable energy consumption, and renewable internal fresh water; three factors of growth including FDI inflows, GDP per capita, and population growth; and four factors of biodiversity loss including average precipitation, forest area, GEF benefits index of biodiversity, and total fisheries production. The study employed panel fixed effect regression that absorb the country invariant time specific shocks while panel quantile regression assess the influencer factors on biodiversity loss in different quantiles distribution. The results show that climatic factors significantly increases aquaculture production whereas energy sources and growth specific factors decreases the aquaculture production at different quantiles regression. Forest area increases by climatic factors, renewable internal fresh water resources, FDI inflows, and GDP per capita while it decreases by renewable energy consumption and population growth. The GEF biodiversity index is affected by average precipitation, FDI inflows and GDP per capita, while nitrous oxide emissions, renewable energy consumption, fresh water resources and population growth stimulate the potential of biodiversity. Finally, total fisheries production increases by climatic factors and renewable energy consumption while it decreases by growth specific factors and renewable internal fresh water resources in a panel of countries.

The weather and extreme temperature increases climatic variations that affected environment and ecosystem across the globe. Asian countries having no exceptions that suffered with severe weather and extreme temperature which deteriorate natural environment and biodiversity loss across countries. In addition, different air pollutants including carbon dioxide emissions and GHG emissions damages the natural flora and biodiversity that required special call for attention to conserve natural resources as per United Nations – Kyoto protocol. The quest for the appropriate energy sources that less sensitive with carbon pollution and climate change is prerequisite in order to conserve natural environment. Renewable energy sources are the optimistic solution for mitigating air pollution and climate change in order to preserve potential habitat area and biodiversity as per environmental sustainability parameters. Climate change impact on biological diversity is highly ignored in strategic policy framework that should be visible in sustainable policy arena for prosperous Asia.

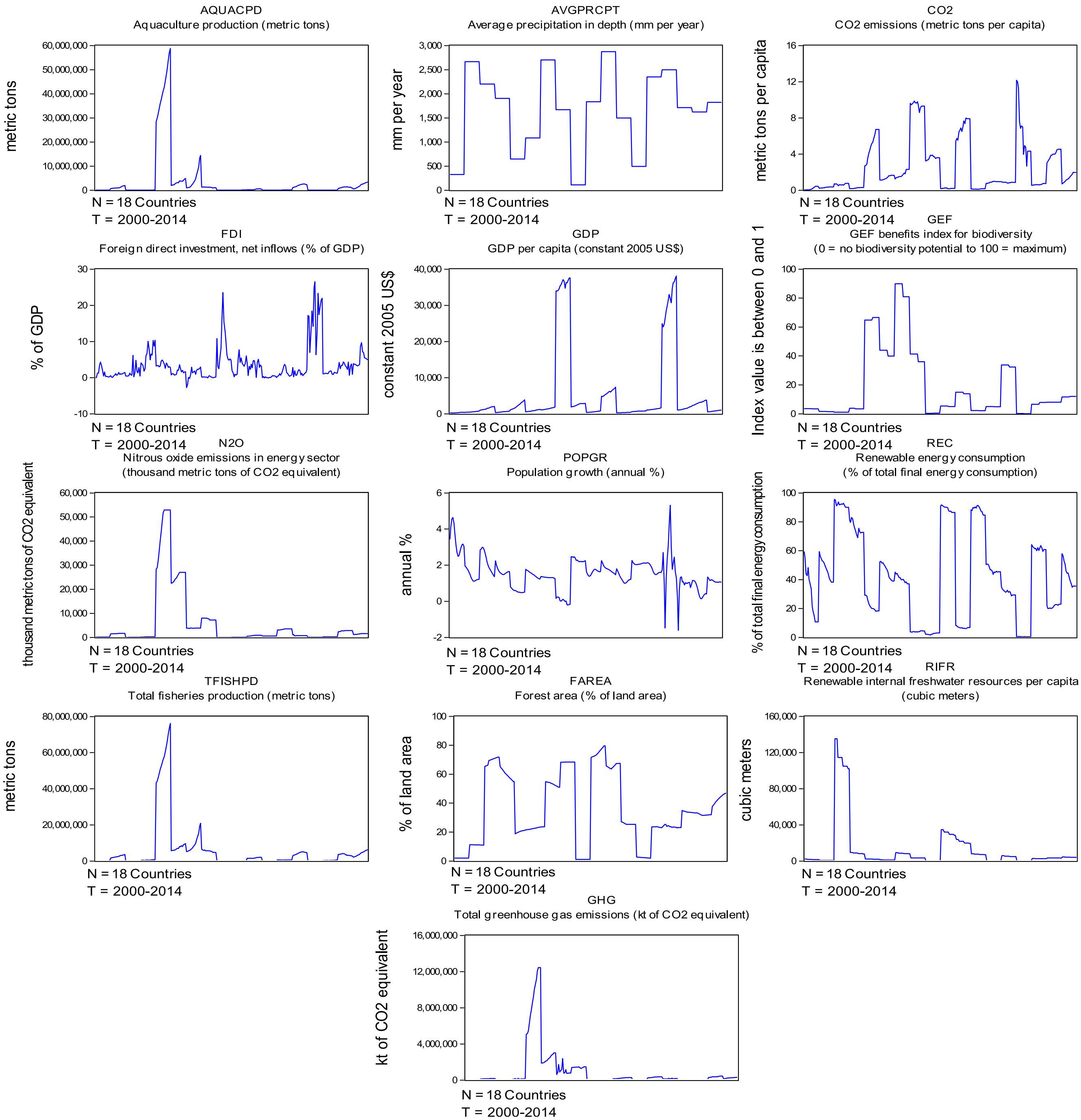
Biodiversity is important for i) balancing the ecosystem, ii) rich source of biological process, iii) provision of societal benefits including food, livestock, medicines, iv) promote heritage and culture, v) enhance recreational activities including travel and tourism, vi) balancing the natural environment, vii) maintaining the temperature and average precipitation rate, viii) managing the threat of global warming, ix) providing fresh and natural water sources etc. The importance of biodiversity and its positive effects required strong policy legislation to promote and sustained biodiversity across the globe. Increasing temperature and rising sea level directly linked with the global climate change that affected aquaculture production, forest area, biodiversity, total fisheries production etc. Sustained and environmental viable programmes to mitigate climate change impact of forest biological diversity and potential habitat area to conserve biodiversity is forefront challenges for Asian countries. The human and economic factors deteriorate the natural environment in a form to increase deforestation and fossil fuel energy combustion that increases the carbon dioxide emissions concentration in atmosphere, which ultimately affected the health, wealth and natural resources of the countries. The policies to preserve ecological animal and plant species required massive attention for sustained biodiversity across countries. To effectively launching a sustainable environmental policy, its required proper land used management, forestry management, ecosystem balances, conserves ecological habitat areas, and reforestation that would ultimately lessen the air pollutants and GHG emissions from the atmosphere. The environmental friendly policies for low carbon economy would facilitate to reduce the concentration of air pollutants and GHG emissions, which further support the natural environment and increasing the potential of biodiversity across the globe.

Appendix

S.No	Appendix No.	Heading
1	I	Figure-A: Plots of Level Data
2	II	Natural Logarithmic Form of Estimated Equations
3	III	Table –A: Descriptive Statistics and Correlation Matrix

Appendix -I

Figure-A: Plots of Level Data.



Source: [62].

Appendix -II

Natural Logarithmic Form of Estimated Equations:

$$\begin{aligned}\ln(AQUACPD)_{it} = {} & \alpha_i + \beta_{i1}\ln(AVGPRCPT)_{it} + \beta_{i2}\ln(CO2)_{it} + \beta_{i3}\ln(GHG)_{it} + \beta_{i4}\ln(N2O)_{it} + \beta_{i5}\ln(REC)_{it} \\ & + \beta_{i6}\ln(RIFR)_{it} + \beta_{i7}\ln(FDI)_{it} + \beta_{i8}\ln(GDP)_{it} + \beta_{i9}\ln(POPGR)_{it} + \nu_i + \psi_t + \varepsilon_{it}\end{aligned} \tag{1}$$

$$\begin{aligned}\ln(FAREA)_{it} = {} & \alpha_i + \beta_{i1}\ln(AVGPRCPT)_{it} + \beta_{i2}\ln(CO2)_{it} + \beta_{i3}\ln(GHG)_{it} + \beta_{i4}\ln(N2O)_{it} + \beta_{i5}\ln(REC)_{it} \\ & + \beta_{i6}\ln(RIFR)_{it} + \beta_{i7}\ln(FDI)_{it} + \beta_{i8}\ln(GDP)_{it} + \beta_{i9}\ln(POPGR)_{it} + \nu_i + \psi_t + \varepsilon_{it}\end{aligned} \tag{2}$$

$$\begin{aligned}\ln(GEF)_{it} = {} & \alpha_i + \beta_{i1}\ln(AVGPRCPT)_{it} + \beta_{i2}\ln(CO2)_{it} + \beta_{i3}\ln(GHG)_{it} + \beta_{i4}\ln(N2O)_{it} + \beta_{i5}\ln(REC)_{it} \\ & + \beta_{i6}\ln(RIFR)_{it} + \beta_{i7}\ln(FDI)_{it} + \beta_{i8}\ln(GDP)_{it} + \beta_{i9}\ln(POPGR)_{it} + \nu_i + \psi_t + \varepsilon_{it}\end{aligned} \tag{3}$$

$$\begin{aligned}\ln(TFISHPD)_{it} = {} & \alpha_i + \beta_{i1}\ln(AVGPRCPT)_{it} + \beta_{i2}\ln(CO2)_{it} + \beta_{i3}\ln(GHG)_{it} + \beta_{i4}\ln(N2O)_{it} + \beta_{i5}\ln(REC)_{it} \\ & + \beta_{i6}\ln(RIFR)_{it} + \beta_{i7}\ln(FDI)_{it} + \beta_{i8}\ln(GDP)_{it} + \beta_{i9}\ln(POPGR)_{it} + \nu_i + \psi_t + \varepsilon_{it}\end{aligned} \tag{4}$$

Appendix III

Table-A
Descriptive statistics and correlation matrix.

Panel -A:	AQUACPD (metric tons)	AVGPRCPT (mm per year)	CO_2 (metric tons per capita)	FAREA (% of land area)	FDI (% of GDP)	GDP (constant 2005 US$)	GEF (0 = No biodiversity potential, 100 = maximum potential)	GHG (kt of CO_2 equivalent)	N_2O (000′ metric tons of CO_2 equivalent)	POPGR (annual %)	REC (% of total final energy consumption)	RIFR (cubic meters)	TFISHPD (metric tons)
Mean	3253972	1667.167	2.451	35.214	3.416	5062.963	18.306	874005.8	5255.933	1.530	41.624	12004.43	5464002
Maximum	58797258	2875	12.166	79.649	26.521	38087.66	89.953	12454711	52936.03	5.321	95.481	135356.2	76149368
Minimum	30	111	0.031	1.098	−2.757	239.699	0.127	1467.573	51.324	−1.609	0.325	103.223	47
Std. Dev.	9884680	820.842	2.867	24.162	4.647	10260.25	24.298	2179027	11548.09	0.892	29.795	26093.33	13270381
Skewness	4.035	−0.417	1.422	0.229	2.696	2.472	1.572	3.896	2.946	0.526	0.286	3.438	3.767
Kurtosis	18.632	2.125	4.062	1.775	10.995	7.386	4.414	18.377	11.051	5.611	1.940	14.108	16.615
Panel −B: Correlation Matrix													
AQUACPD	1												
AVGPRCPT	−0.254	1											
CO2	0.233	0.101	1										
FAREA	−0.128	0.578	0.204	1									
FDI	−0.019	0.044	0.255	−0.106	1								
GDP	−0.069	0.192	0.741	0.206	0.385	1							
GEF	0.559	0.087	0.229	0.139	−0.239	0.049	1						
GHG	0.963	−0.292	0.298	−0.103	−0.058	0.007	0.600	1					
N2O	0.883	−0.343	0.243	−0.155	−0.089	−0.021	0.605	0.955	1				
POPGR	−0.293	−0.175	−0.345	−0.290	0.190	−0.212	−0.350	−0.332	−0.318	1			
REC	−0.182	0.103	−0.734	0.303	−0.345	−0.527	−0.230	−0.208	−0.184	0.077	1		
RIFR	−0.115	0.261	−0.159	0.529	−0.127	−0.127	−0.174	−0.139	−0.165	0.193	0.493	1	
TFISHPD	0.995	−0.232	0.263	−0.104	−0.047	−0.043	0.624	0.968	0.899	−0.335	−0.212	−0.137	1

Note: AQUACPD indicates aquaculture production, AVGPRCPT indicates average precipitation, CO2 indicates carbon dioxide emissions, FAREA indicates forest area, FDI indicates Foreign Direct Investment inflows, GDP indicates per capita GDP, GEF indicates GEF benefits biodiversity index, GHG indicates Greenhouse Gas emissions, N2O indicates nitrous oxide emissions, PPOPGR indicates population growth, REC indicates renewable energy consumption, RIFR indicates renewable internal fresh water resources, and TFISHPD indicates total fisheries production. Mean = $\left(\frac{\sum x_i}{n}\right)$, Standard Deviation (SD) = $\sqrt{\frac{I}{N}\sum_{i=1}^{N}(x_i-\overline{x})^2}$, Skewness = (3 × (mean - median))/standard deviation, Kurtosis (K) is the ratio of forth moment and variance squared, i.e., $K = \frac{m_4}{(\sigma^2)^2}$, Correlation coefficient (r) = $\frac{n(\sum xy)-(\sum x)(\sum y)}{[(nx\sum x^2)-(\sum x^2)][n\sum y^2-(\sum y^2)]}$.

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